

The Public Health Consequences From Acute Chlorine Releases, 1993–2000

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Abstract

Chlorine, a commonly used hazardous substance, can be harmful to human health when improperly released. Data from the Agency for Toxic Substances and Disease Registry's Hazardous Substances Emergency Events Surveillance (HSEES) system were used to conduct a retrospective analysis on the public health consequences from acute chlorine releases in 16 states during 1993 through 2000. There was an overall decline in the number of chlorine events during the period analyzed; however, chlorine events were more likely to result in events with victims, evacuations, and decontaminations when compared with non-chlorine events (relative risk [RR] = 4.5, 95% confidence interval [CI] = 4.1–5.0; RR 4.8, CI 4.3–5.3; and RR 2.0, CI 1.7–2.4, respectively). Most chlorine victims were employees and members of the general public. The predominant symptoms sustained were respiratory and eye irritation. Equipment failure and human error were the most frequent factors leading to an event. Continuous employee training and preventive equipment maintenance can help prevent chlorine releases from occurring and minimize exposure to the general public.

Introduction

- Chlorine, a highly reactive inorganic gas, is one of the top ten chemical substances produced in the United States; approximately 25 billion pounds are produced annually (1).
- It is widely used as a water disinfectant, a bleaching agent for paper and cloth and as an intermediate in the manufacture of many organic products including rubber, cleaning agents, and pharmaceuticals (2, 3).
- Human exposure to chlorine releases occurs primarily through inhalation, skin, and/or eye contact (4).
- Symptoms from acute chlorine exposure include burning eyes, nose, mouth; lacrimation, rhinorrhea, cough, choking, substernal pain; nausea, vomiting; headache, dizziness; syncope; pulmonary edema; pneumonitis; hypoxemia; dermatitis; and frostbite (4).

Methods

From 1993 to 2000, 16 state health departments participated in the active HSEES system collecting information (i.e., substance[s] released; number of victims, injuries, and evacuees) about hazardous substances events. An event was defined as any release(s) or threatened release(s) of at least one hazardous substance. A substance was considered hazardous if it might reasonably had been expected to cause an adverse human health effect. Various data sources used by states to collect event information included, but were not limited to, state environmental protection agencies, police and fire departments, hospitals, and local media. For this analysis, the HSEES database was queried for all events that were grouped in the hazardous substance category *chlorine*. To assess these public health consequences specific to chlorine, the analysis was restricted to events where only chlorine was released.

Results

See Tables 1 – 4

Case Vignette

Pulp, paper, and paperboard mills event. In March 1993, a four inch joint pipeline gasket failed at a North Carolina paper/pulp mill allowing the release of 2,298 pounds of chlorine gas. Seventeen employees sustained respiratory irritation, eye irritation, and nausea. Fourteen of the employees were treated on-scene with first aid. Three employees were treated at a hospital, but were not admitted. Eighty employees were evacuated from the building for four hours.

Discussion

- In the HSEES database, chlorine has consistently been among the top individual substances released, yet, from 1993 to 2000, the number of chlorine events has decreased.
- Most of the downward trend in chlorine events can be attributed to a decline in events in four of the top five industry sub-categories: *industrial and miscellaneous chemicals*; *sanitary services*; *pulp, paper and paperboard mills*; and *miscellaneous entertainment and recreation services*.
- Reasons for the decrease in events may have included the pulp industry and various water treatment facilities switching from chlorine to alternative substances (i.e., ozone, hydrogen peroxide), the adoption of pollution controls, technological upgrades, safety improvements by chlor-alkali industries, and/or the implementation of risk management plans (RMPs) by industry under the regulation of the US Environmental Protection Agency (EPA) (5–9).
- Certain chlorine events appear to follow seasonal trends, with the number being highest from May through August, with a peak occurring in June.
- Most of the victims from chlorine events were injured occupationally, of which a high percentage were not wearing PPE at the time of injury.
- The general public tended to have been exposed to chlorine where it was used for recreational purposes (i.e., swimming pools).

Limitations

- The reporting of events to participating HSEES states is not mandatory; therefore, participating states may not be informed about every event.
- Each HSEES state has different minimum substance quantity reporting guidelines; therefore, small releases in some states may go unreported.

Conclusion

While the uses of chlorine are numerous, when mishandled, hazardous substances, such as chlorine, can have serious adverse public health consequences. Findings from this analysis suggest that certain public health actions can be taken by local government, industry, and first-responders to help reduce the number of chlorine-related injuries.

- Employee groups at risk for chlorine exposure (i.e., employees in pulp/paper mill manufacturing and chemical manufacturing and first responders) could be targeted for proper hazmat training and appropriate PPE usage, where necessary.
- Thorough preventive maintenance on processing equipment that use chlorine and other hazardous substances should be routinely conducted.
- Industries should attempt to utilize the latest technological advances for preventing and/or minimizing chlorine and other hazardous substances releases (i.e., electrochemical gas detectors, containment systems, treatment systems such as scrubbers and absorption tanks) (10).
- Industries should explore using alternatives to hazardous substances, where feasible.
- Using information gathered from HSEES can be used to help pinpoint where potential releases of chlorine, and other hazardous materials, could occur in the future.

Table 1: Distribution of chlorine events compared with non-chlorine HSEES events, by year

Year	No. of Participating states	Chlorine events*				Non-chlorine events†			
		Events	% of total	Events with victims	% of yearly events with victims§	Events	% of total	Events with victims	% of yearly events with victims§
1993	11	120	13.9	38	31.7	3365	8.3	368	10.9
1994	12	129	14.9	42	32.6	3654	9.0	316	8.6
1995	14	133	15.4	43	32.3	4809	11.8	302	6.3
1996	14	105	12.1	32	30.5	5120	12.6	302	5.9
1997	13	107	12.4	34	31.8	5142	12.7	284	5.5
1998	13	95	11.0	28	29.5	5620	13.8	301	5.4
1999	13	78	9.0	27	34.6	5933	14.6	408	6.9
2000	15	98	11.3	31	31.6	6963	17.1	591	8.5

* Includes events where only chlorine was involved.

† Includes non-chlorine events involving one substance only.

§ Number of events with victims ÷ number of events.

Table 2: Distribution of chlorine events by HSEES state*

Participating states	Chlorine events	
	Number	Percent of total
Alabama	60	6.9
Colorado	23	2.7
Iowa	32	3.7
Minnesota	38	4.4
Missouri	20	2.3
Mississippi	54	6.2
North Carolina	75	8.7
New Hampshire	5	0.6
New Jersey	12	1.4
New York	92	10.6
Oregon	92	10.6
Rhode Island	12	1.4
Texas	139	16.1
Utah	5	0.6
Washington	131	15.1
Wisconsin	75	8.7
Total	865	100.0

* Includes events where only chlorine was involved.

Table 3: Distribution of chlorine events and victims, by major industry category

Major industry category	Events		Events with victims		No. of victims		Victims per event*
	No.	%	No.	%	No.	%	
Manufacturing	387	44.7	104	37.8	397	37.1	3.8
Transportation, communications, and other public utilities	255	29.5	59	21.5	124	11.6	2.1
Entertainment and recreation services	62	7.2	33	12.0	190	17.7	5.8
Professional and related services	31	3.6	15	5.5	91	8.5	6.1
Personal services	30	3.5	19	6.9	36	3.4	1.9
Wholesale trade	23	2.7	9	3.3	75	7.0	8.3
Retail trade	18	2.1	10	3.6	43	4.0	4.3
Public administration	18	2.1	9	3.3	49	4.6	5.4
Active duty military	9	1.0	1	0.4	26	2.4	26.0
Business and repair services	8	0.9	4	1.5	12	1.1	3.0
Construction	5	0.6	0	0.0	0	0.0	0.0
Finance, insurance, and real estate	4	0.5	3	1.1	9	0.8	3.0
Mining	2	0.2	1	0.4	1	0.1	1.0
Agriculture, forestry, and fisheries	1	0.1	1	0.4	6	0.6	6.0
Unknown industry	12	1.4	7	2.5	12	1.1	1.7
Total	865	100.0	275	100.0	1071	100.0	3.9

* Number of victims ÷ number of events with victims.

Table 4: Distribution of all events and a univariate analysis of events with victims, by substance category

Hazardous substance category	Events		Events with victims		Relative Risk†	95% Confidence Interval	Proportion of events with victims‡
	No.	% of total	No.	% of total			
Chlorine	865	2.1	275	8.7	4.5	4.1 - 5.0 [§]	31.8
Ammonia	2845	6.9	376	11.9	1.8	1.7 - 2.0 [§]	13.2
Acids	3716	9.0	440	14.0	1.7	1.5 - 1.8 [§]	11.8
Pesticides	1940	4.7	223	7.1	1.6	1.4 - 1.8 [§]	11.5
Bases	1567	3.8	114	3.6	1.0	0.8 - 1.2	7.3
Other	8315	20.1	584	18.6	0.9	0.8 - 1.0	7.0
Mixtures across categories	3971	9.6	259	8.2	0.9	0.8 - 1.0	6.5
Other inorganic substances	8567	20.7	514	16.3	0.8	0.7 - 0.8 [§]	6.0
Paints and dyes	1011	2.4	41	1.3	0.5	0.4 - 0.7 [§]	4.1
Volatile organic compounds	7751	18.7	311	9.9	0.5	0.4 - 0.5 [§]	4.0
Polychlorinated biphenyls	923	2.2	10	0.3	0.1	0.1 - 0.3 [§]	1.1
Total	41,471 [§]	100.0	3147	100.0	—	—	7.6

* Comparison of substance category victim events with victim events in all other substance categories.

† Events with victims - events.

‡ Includes significant at 0.05.

§ Includes events where only one substance was involved (n=41,471/44,164, 93.9%).

References